AD-A169 846 HIGH REPETITION RATE ELECTRON BEAM RF-ACCELERATION AND SUB-MILLIMETER WAV..(U) CALIFORNIA UNIV LOS ANGELES N C LUHMANN ET AL. 14 FEB 86 N00014-84-K-0569 1/1

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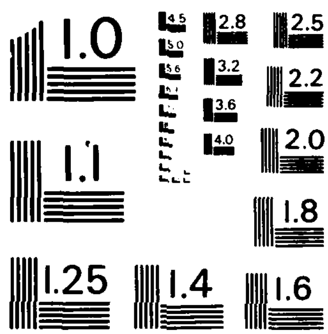
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SEMI-ANNUAL PROGRESS REPORT

1. ONR Proposal Number: P-5610-N-84

2. Period Covered by Report: 15 August, 1985 - 14 February, 1986

3. Title of Proposal: High Repetition Rate Electron Beam RF-Acceleration and Sub-Millimeter Wave Generation via a Free Electron Laser

4. Contract or Grant Number: N00014-84-K-0569

5. Name of Institution: University of California, Los Angeles

6. Author(s) of Report: N.C. Luhmann, Jr. and D.B. McDermott

7. List of Manuscripts Submitted or Published under ONR Sponsorship During This Period, Including Journal References:

   (a) D.B. McDermott, W.J. Nunan and N.C. Luhmann, Jr., "A High Duty Cycle, Compact 94 GHz Free Electron Laser," submitted to Journal IR and mm-Waves.

   (b) W.J. Nunan, D.B. McDermott and N.C. Luhmann, Jr., "A High Repetition Rate, Compact 94 GHz Free Electron Laser," Bulletin of the American Physical Society <u>30</u>, 1543 (1985).

   (c) D.B. McDermott, W.J. Nunan and N.C. Luhmann, Jr., "A High Repetition Rate 94 GHz Free Electron Laser", Digest of Tenth Int. Conf. on IR and mm-Waves, IEEE #85CH2204-6, 46 (1985).

(d) D.B. McDermott, W.J. Nunan and N.C. Luhmann, Jr., "A High Repetition Rate Compact 94 GHz Free Electron Laser," Proc. of 1985 IEEE IEDM Meeting IEEE #85CH2252-5, 544 (1985).

(e) N.C. Luhmann, Jr., D.B. McDermott, D.S. Furuno and W.J. Nunan, "Compact, High Power Millimeter Wave Sources," to be published in Proc. of Sixth Int. Conf. High-Power Particle Beams, Osaka, Japan 1986.

8. Scientific Personnel Supported by This Project and Degrees Awarded During This Reporting Period: Prof. N.C. Luhmann, Jr.

Dr. D.B. McDermott

W.J. Nunan (Ph.D. Student)

I. THEORY

Thermalization of the electron beam must be avoided for efficient FEL operation. For this reason the amplitude of the undulator's magnetic field, the FEL pump, must be gradually tapered at its front end. The trajectory of an electron entering a tapered undulator has been numerically simulated. The undulator's amplitude has been approximated by a linear taper.

$$B(z) = \begin{cases} 0 & z < 0 \\ \left(\frac{z}{L}\right) B_o (\hat{x} \cos kz + \hat{y} \sin kz) & 0 < z < L \\ B_o (\hat{x} \cos kz + \hat{y} \sin kz) & z > L \end{cases}$$

The dependence of the beam's thermalization on the taper length, L, is shown in Fig. 1. On account of this data we have chosen to conduct our experiment with a taper of 50 cm.

We have continued to investigate through numerical simulation the advantages of a <u>multicavity</u> linac for improving the quality of the electron beam due to the technique of phase synchronism. This will also increase the shunt resistance of the accelerator which is desirous if very high energy is the goal. However, if a particular energy is required, then the shunt resistance must be held constant. Fortunately, a cavity's quality factor, Q, is approximately inversely proportional to its length if its aspect ratio is much less than one. Therefore, the shunt resistance can be controlled by varying the length of the cavities.

II. Experiment

The accelerator and buncher cavities, RF feeds, and drift tubes have been brazed to flanges. We are now attempting to synchronize the resonant frequencies of the buncher and accelerator cavities. A cavity's TM_{010} frequency can be decreased by either overcouping or increasing its diameter. These are both fine tuning techniques. However, the accelerator cavity presently exhibits an anomously low 1) TM_{010} resonant frequency and 2) unloaded Q. We suspect the RF path is not continuous along the entire cavity, especially where the cavity is attached to a flange. Contact should be assured after some touch up machining is performed.

The machining of a 3 cm period, electromagnetic undulator with a 97%, 0.5 m amplitude taper region and a total length of 2 m is continuing. The undulator's frame is a teflon rod with a bifilar helical groove wide and deep enough to hold four insulated 12 gauge wires. We have calculated that the resultant inductance yields a cycle time ($\approx$ 50 μs) which is long enough that the magnetic field will penetrate through the 1.6 mm thick stainless steel wall of the interaction tube ($\approx$ 4 μs) and will be approximately flat during the rf accelerator pulse ($\approx$ 5 μs).

The 20 W cw, 94 GHz extended interaction oscillator (EIO), recirculating coolant system and power supply have arrived, been integrated and tested. This tube will serve as the input for the FEL amplifier experiment.

A High Duty Cycle, Compact 94 GHz Free Electron Laser

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Department of Electrical Engineering

University of California, Los Angeles, CA 90024

The design of a practical free electron laser (FEL) is described in which the electron beam is accelerated in a standing-wave rf-linac. The maximum duty cycle, 0.2%, is determined by the rf driver, a 5 MW, 1.3 GHz magnetron. The initial single cavity linac will accelerate electrons to an energy of up to 2 MeV at a micropulse current of 100 A and an average macropulse current of 1 A. The initial two experiments will be an FEL amplifier and an FEL oscillator at 94 GHz.

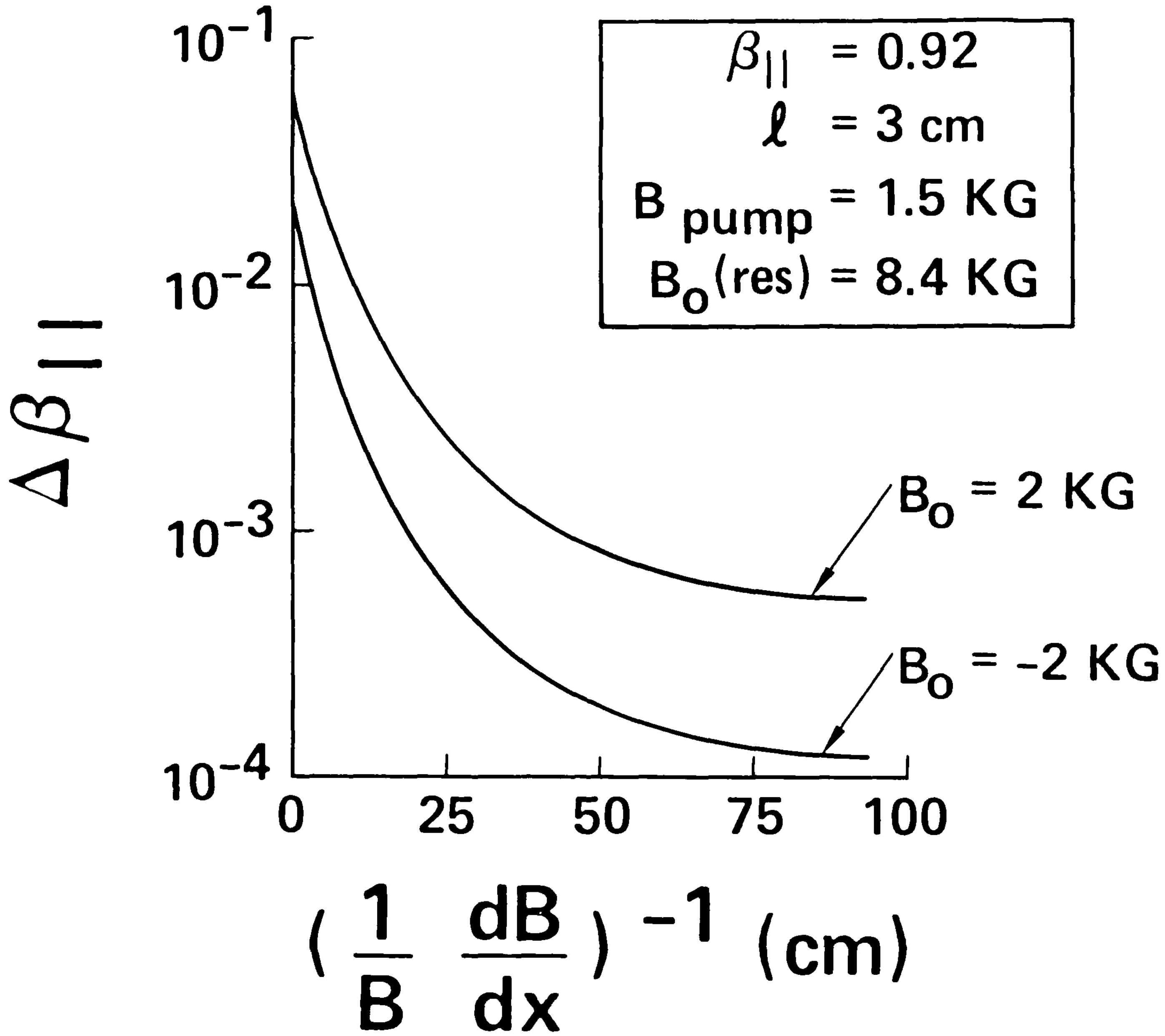

Figure 1 Dependence of parallel velocity spread on scale length of amplitude of tapered undulator.

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